AD-A094 866 NAVAL RESEARCH LAB WASHINGTON DC F/G 4/1
FIELD COMPARISONS OF PYROTECHNICALLY GENERATED FOGS.(U)
FEB 81 S G GATHMAN, B G JULIAN, R K MARKSON
UNCLASSIFIED NRL-MR-4443 NL

1 OF 1
AD A
094166

END
DATE
FILMED
3-81
DTIC

NRL Memorandum Report 4443

Field Comparisons of Pyrotechnically Generated Fogs

S. G. GATHMAN AND B. G. JULIAN

Atmospheric Physics Branch
Environmental Sciences Division

and

R. K. MARKSON AND J. SEDLÀĈEK

Airborne Research Associates
Weston, MA 02193

February 18, 1981

NAVAL RESEARCH LABORATORY
Washington, D.C.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NRL Memorandum Report 4443	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FIELD COMPARISONS OF PYROTECHNICALLY GENERATED FOGS		5. TYPE OF REPORT & PERIOD COVERED Interim report on a continuing NRL problem.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. G. Gathman, B. G. Julian, R. K. Markson* and J. Sedlacek*		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Research Laboratory Washington, DC 20375		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N; WR 01137; 43-1114-0-1
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Washington, DC 20361		12. REPORT DATE ~~February 18,~~ 1981
		13. NUMBER OF PAGES 42
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

*Present address: Airborne Research Associates, 46 Kendal Common Road, Weston, MA 02193

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Salty dog
Hygroscopic nuclei
Stabilization
Scattering coefficient
Relative humidity
Plume
Diffusion
Surfactant

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Comparisons between some physical characteristics of water fogs produced in several ways from pyrotechnically generated hygroscopic nuclei are presented. These results were obtained from a series of 31 plume experiments off Nantucket during 8—12 June 1979. The comparisons include the maximum scattering of the fogs at optical wavelengths, the duration of the fogs and the detection of larger droplets in the fogs. The results show that significant physical properties of the resultant water fogs can be modified by both the production process and/or the chemical formulation of the pyrotechnic material.

CONTENTS

BACKGROUND

The Navy needs an improved capability for utilizing the environment as a countermeasure for increased use of electrooptics systems. While other services concentrate their efforts on aerosol countermeasures applicable to battlefield dust, smoke and atmospheric dirt, the Navy needs to consider the atmospheric environment over the ocean where high relative humidity exists all the time and where optical depth of 10 km already are detrimental to most electrooptical systems. Hygroscopic nuclei acquire, in a humid atmosphere, theoretically a much higher mass by condensational growth than do phosphorus particles in an oxidation process. Technological problems are pyrotechnic methods to dispense hygroscopic materials in large quantities with optical particle sizes. Testing of the behavior of these aerosols in the true marine environment as opposed to chamber tests is necessary because of vapor depletion problems in enclosed structures of finite volume.

FIELD COMPARISONS OF PYROTECHNICALLY GENERATED FOGS

I. INTRODUCTION

A limited field experiment was undertaken in September 1978 to demonstrate the potential usefulness as a screening agent of a pyrotechnical material known as "Salty Dog" to produce artificial water fogs at the sea surface (Gathman, et al, 1979), (Gathman, S., 1980). These tests showed that it was possible in a special environment to grow a droplet on a pyrotechnically generated hygroscopic nucleus and then to stabilize the droplet to prevent evaporation. This droplet is larger than it would have been if it were to have been grown in the ambient drier subsaturated natural environment.

The work described in this report is a continuation of the original work extending the data base in order to reduce the possibilities of random statistical variations causing erroneous results. In the period of time between the two experiments the people at the Naval Weapons Center at China Lake, California (Mathews, and St. Amand 1980) developed a new and apparently more efficient formulation of the pyrotechnic material referred to in this report as NWC29 and therefore this field test will not only cover the effectiveness of the process of growing and stabilizing pyrotechnically generated sea fogs but to also compare the effectiveness of the two formulations in the field environment. New batches of the old "Salty Dog" material will be referred to as CY85A.

The field test was again carried out on Nantucket Island, Massachusetts where the long low spit of sand (Figure 1) leading from the inhabited part of the island to Great Point makes an ideal and safe location on which to originate plumes of fog which under normal wind conditions drift out over the waters of the Atlantic. Here their time history can be followed by the instrumented aircraft conveniently based at its home airport on the mainland.

Manuscript submitted October 23, 1980.

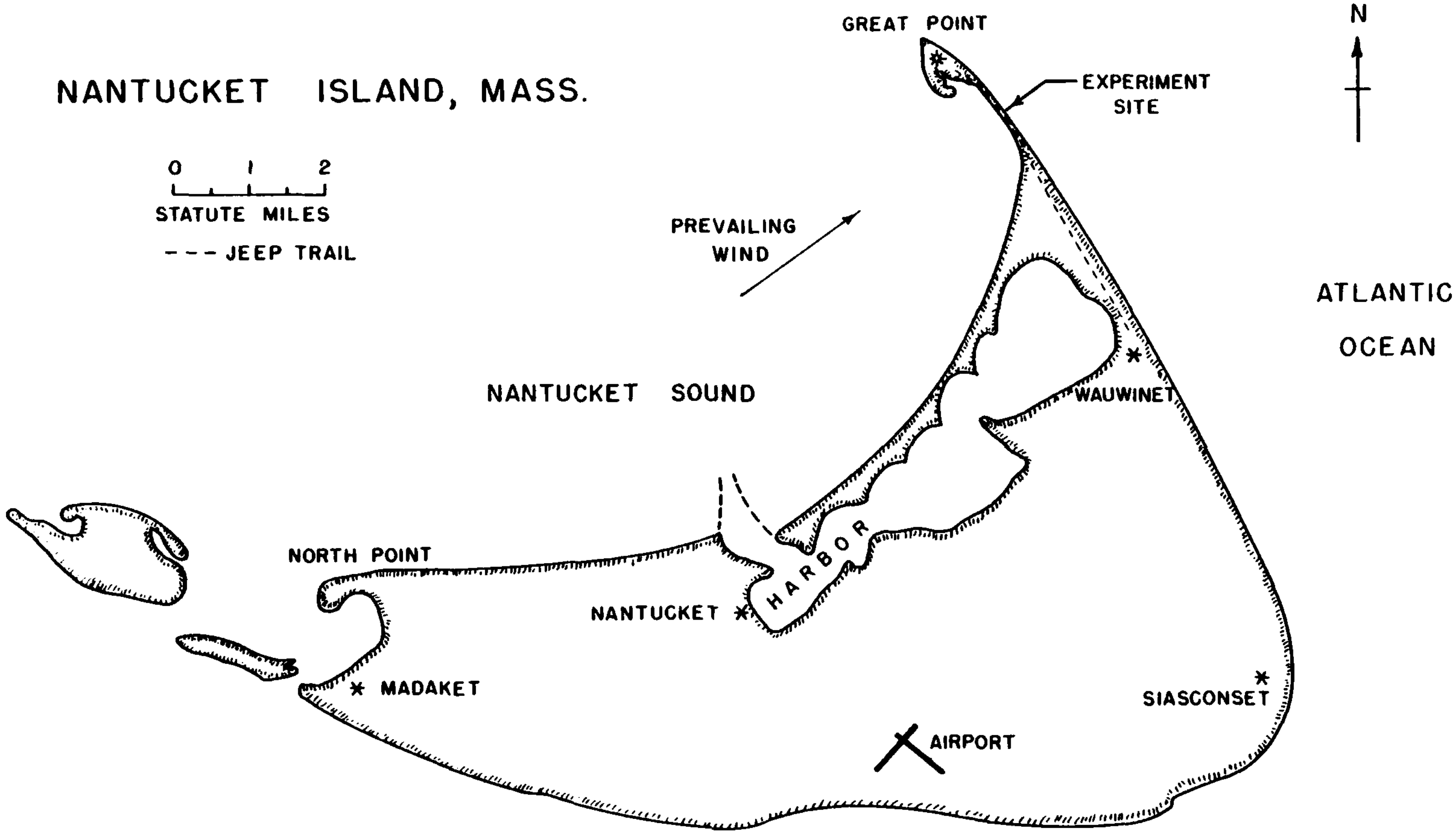


Fig. 1. Nantucket Island, Mass.

Although the general technique of the experiment was the same as used in the preliminary 1978 experiment, an increased effort was made to decrease the experimental difficulties in obtaining a precise knowledge of the meteorological background encountered at the field site. This was accomplished by having a more complete suite of instrumentation assembled for this experiment. Additional instrumentation was added both to the aircraft and the mobile ground observatory.

The aircraft was equipped with both a precision vortex thermometer and a faster responding though less accurate Rosemount temperature probe. A Cambridge model 137-C3 hygrometer was used to measure the dewpoint. A Barnes PRT-5 infrared thermometer was used to measure the ground surface temperature. Altitude was recorded by a pressure sensitive device.

The aircraft was equipped to detect atmospheric aerosol using two different principles. These instruments have overlapping areas of sensitivity to droplet size and this provides a rough indication of the size characteristics of the particular fog or cloud being penetrated by the aircraft. When there is no indication on either instrument we know that all of the particles are of a size less than the minimum detectable. As the sizes of the droplets increase first the MRI model 1550-B integrating nephelometer is activated. As the sizes continue to increase, the electrostatic droplet surface area indicator starts detecting the droplets and finally as the droplets grow to radii greater than 2 microns, (into the size ranges of natural fogs) the integrating nephelometer is no longer sensitive and only the electrostatic detector is in operation. The electrostatic droplet surface area detector described in the appendix is a special purpose instrument designed for aircraft use but based on the principles of a hand held instrument of Vonnegut et al (1957).

The data from the aircraft instrumentation was recorded in analog strip chart format throughout the whole experiment and was used as a backup as well as for an instantaneous flight path evaluation. After the first day all data was also recorded digitally on cassette tape using an airborne HP 9825 computer in a format useful for post experiment analysis.

On the ground the experiment was also improved by the addition of a device for the precise timing of the plume production. In addition, vertical profiles of the wind speed and direction were obtained using the TALA* system, a hand held wind measuring device.

II. EXPERIMENTAL PROCEDURE

The experiment was designed to observe various physical characteristics of a plume of droplets as they evolved in time while they traveled with the wind in the free oceanic environment. As before the plume was produced by a pyrotechnical hygroscopic nuclei generator at a fixed point on the spit of sand on Nantucket Island. Once generated, the plume traveled downwind with the natural air motions. A time history of the plume was obtained by the use of the instrumented aircraft which would systematically fly through the plume recording as a function of time the important physical parameters. The motion of the aircraft penetrating through the plume will tend to speed up somewhat the disintegration of the plume due to eddy diffusion processes. From our observations, the extra diffusion from a penetration was apparently small in comparison with the natural processes at work. In any event, the comparison between methods and processes (the requirements of this study) is in a relative sense insensitive to these penetrations as these external factors are common to all components in the set of experiments.

The timing of the plume measurement events was maintained by the aircraft clock. The timing of the burning of the pyrotechnic was timed by a surface based recorder observing the optical opacity of a path on the outlet of the Nantucket fog stove. A synchronization of the two clocks was done by equating the observed time of aircraft penetration of a plume.

*TALA is the acronym for Tethered Aerodynamically Lifting Anemometer. (U.S. Pat. # 4,058,010)

The position of the plume with respect to the generator site is easily obtained by timing the flight time between a pulse on the PRT-5 generated by a pass over the generator site and the pulses of the droplet detectors generated by the plume itself. The infrared thermometer looking at the sea surface gives a very clear timing pulse when it is flown from over the surface of the water to over the hot ($42^{o}C$) sand of the spit and back. This maneuver was part of the race track flight path used in studying these plumes.

Figure 2 is an actual analog record of the important airborne parameters during an experiment at a time when the plume is very close to the generator site. The passage over land is indicated by the sharp pulse in the infrared surface temperature. A dramatic sea surface temperature gradient is observed on the Atlantic side of the sand bar. This is an interesting phenomena which will help thermally to stabilize the flow in this region. The first detection of the plume is with the electrostatic droplet surface area meter which quickly saturates itself because of an overload. Shortly after this event the integrating nephelometer starts seeing the visible wave length scatter from the droplets which builds up to a peak and then retreats again.

Figure 3 shows the same airborne measurements with respect to time when the plume has an age of 12 minutes. Here the aircraft takes almost 1 minute to reach the plume after leaving the generation site. The electrostatic droplet surface area meter does not detect the smaller droplets remaining in the plume but the scattering from the nephelometer is easily discernible but it has of course been degraded by the diffusion processes.

III. METEOROLOGICAL DESCRIPTION

*** 8 June 1979 ***

The first day was the driest of all of the days of the experiment with a measurement of 56% relative humidity at the beach at 1100 EDT. There was a bright clear sky with the barometer rising through a reading of 30.5" of Hg. at the time of the experiments. Water temperatures measured with an

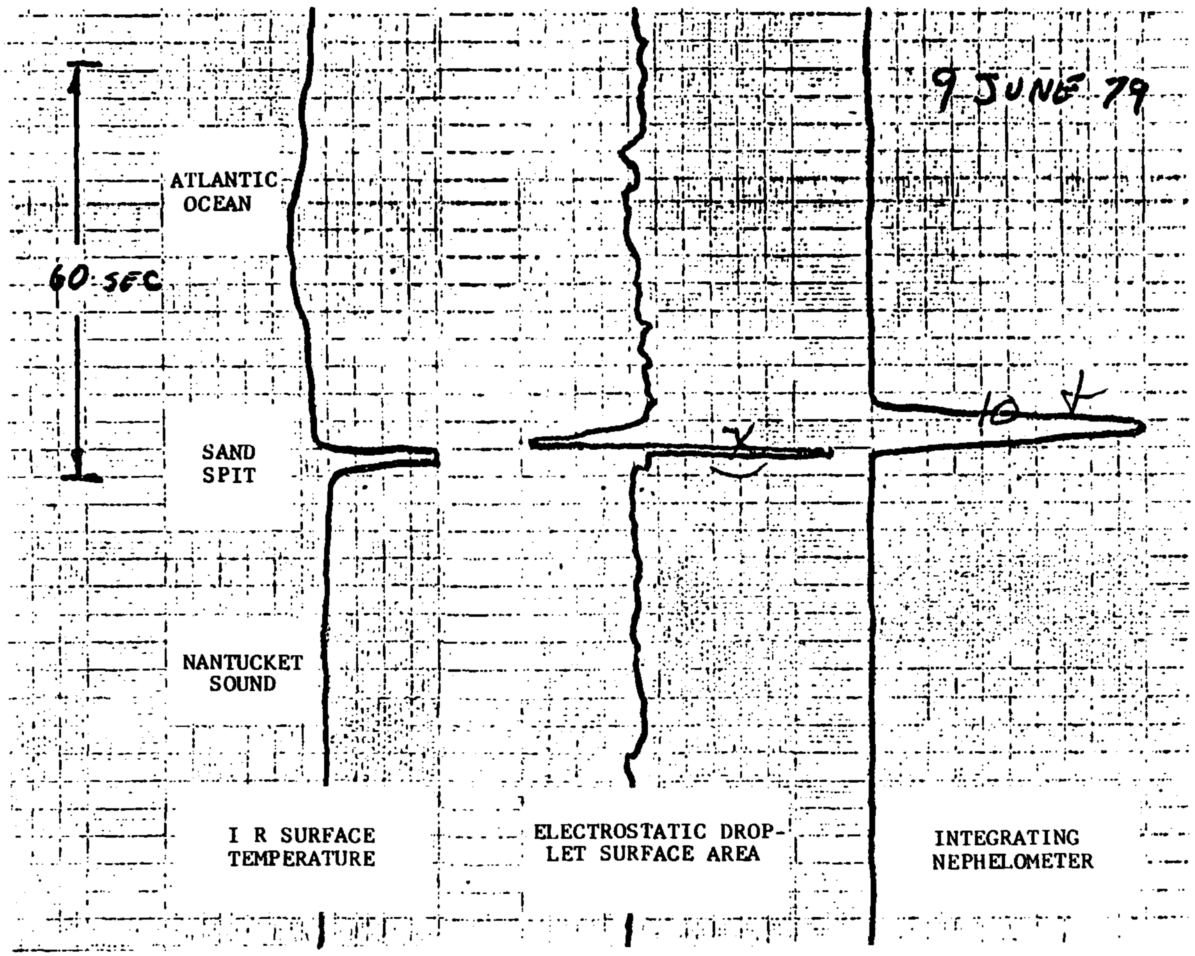


Fig. 2. Chart recording of aircraft instruments at time of newly formed fog plume.

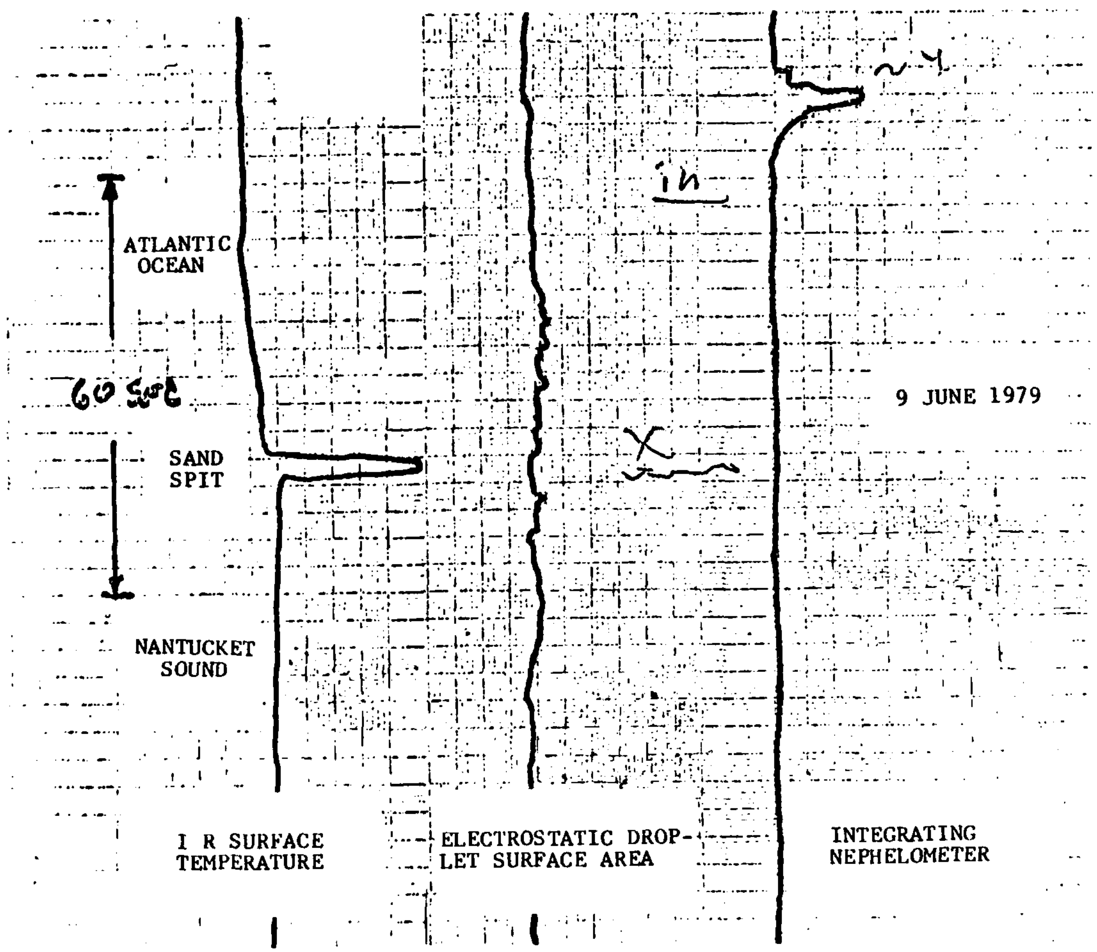


Fig. 3. Chart recording of aircraft instruments for aged fog plume.

infrared thermometer (Barnes PRT - 10) showed the surface temperatures of the Atlantic Ocean to be 12 C whereas the surface temperatures of the sand measured 29 C.

The wind was from a magnetic bearing of 340 degrees. The wind profile (Figures 4a,b) shows a wind shear up to an altitude of 80 meters where the wind speed was approximately constant at 21 miles per hour at altitudes above 80 meters and did not vary appreciably with time from the profile taken before the first plume to that after the last plume of the day. The temperature profile over the Atlantic (Figure 4c) shows a strong surface inversion up to 80 meters. The relative humidity profile from the aircraft (Figure 4d) on the other hand shows a confused state of affairs above the 80 meters mark with measurements ranging from 40% to 70%. Auxiliary psychrometric relative humidity measurements made at the surface and from the aircraft window confirm the readings from the aircraft's vortex thermomenter and dewpointer. This observation leaves us with the conclusion that very dry portions of continental air still exist in this coastal environment and the air mass had not yet been modified into a uniform marine air mass.

Even below the inversion level an average relative humidity measurement of 60% indicates that indeed this is a very dry environment in which to introduce the artificial water fogs. The turbulence factor was also highly effective on this day and will tend to increase the diffusion of the one (dimensional) artificial plumes.

One other interesting feature of this day is the existence of a high scattering level from continental aerosol layers at the levels of 700 meters and above 1100 meters which were detected by the aircraft nephelometer during the sounding process.

Six experimental plumes were run on this day including both the NWC29 and the CY85A "Salty Dog" formulations as the base nuclei. Unstabilized droplets as well as droplets stabilized with both a spray application of Cetyl alcohol, and the Froststop treatment as described by Gathman, et al, (1979) were used. In general the plumes on this day were short lived and consequently the timing of the plume was difficult to accomplish accurately.

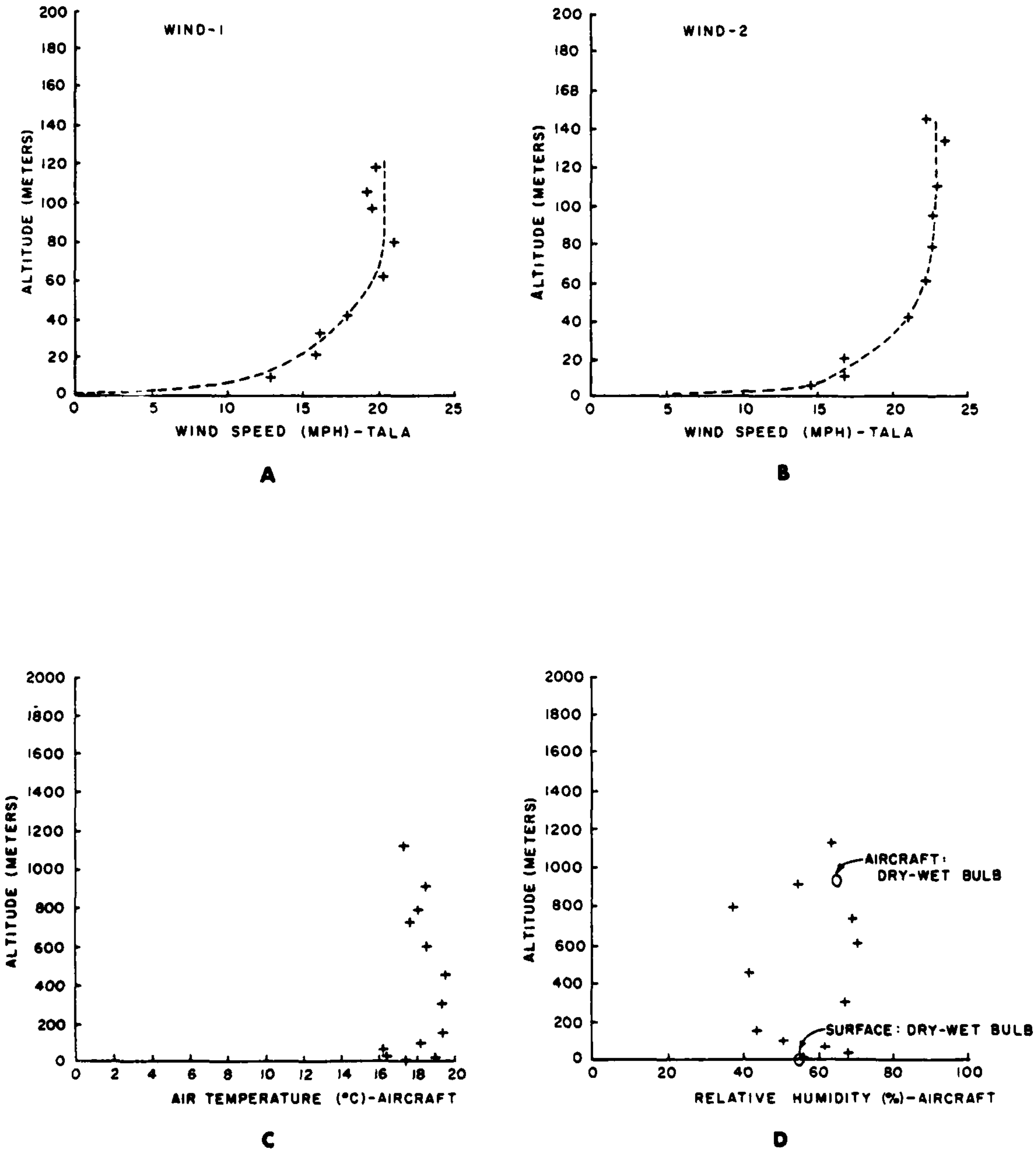


Fig. 4. Meteorological conditions on 8 June 1979.

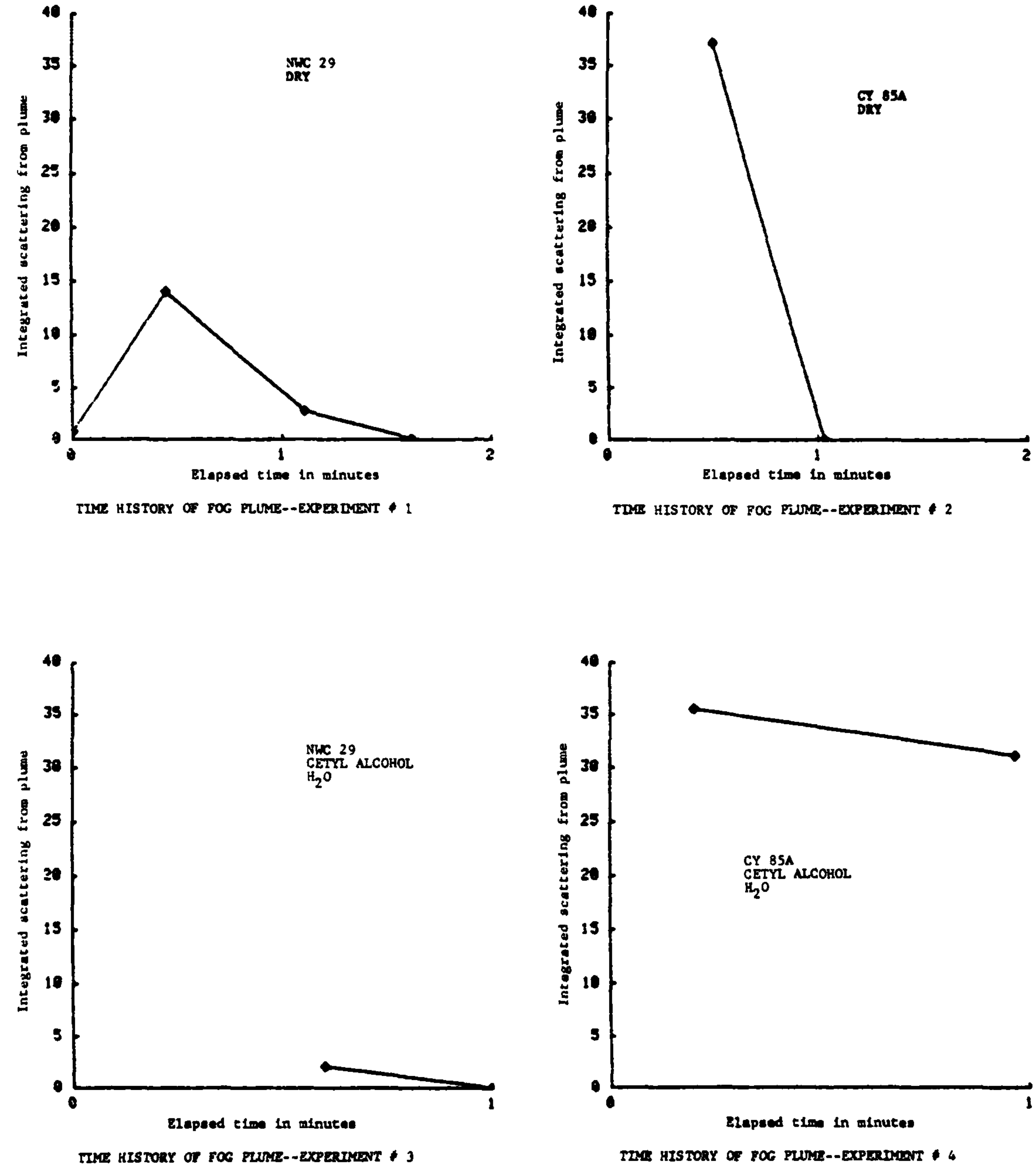


Fig. 5. Time histories of fog plumes 1, 2, 3, 4. (8 June 1979)

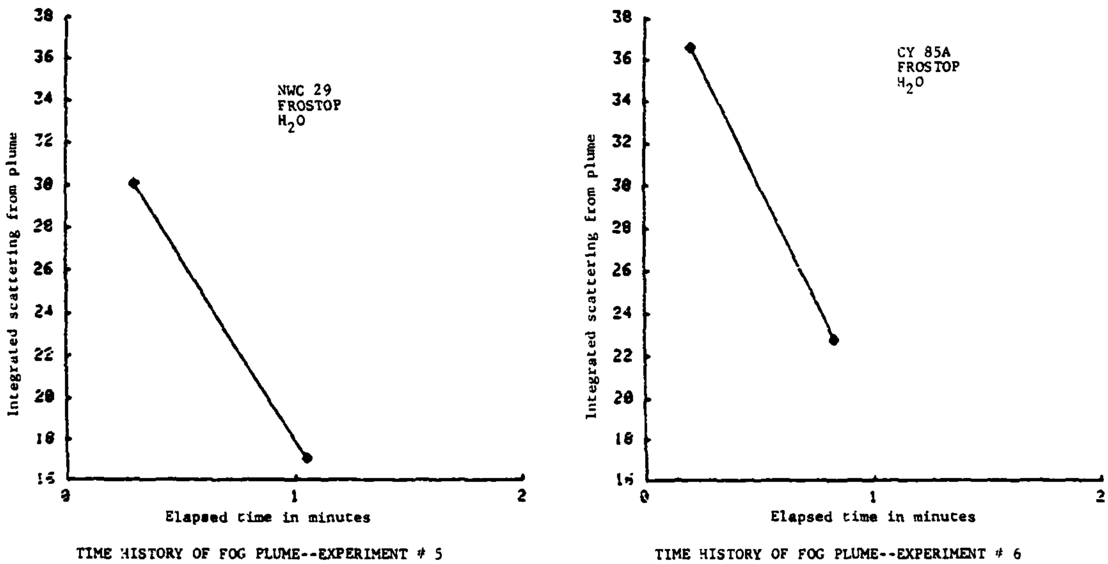


Fig. 6. Time histories of fog plumes 5, 6. (8 June 1979)

However the intercomparison of the runs with each other showed certain conclusions which are discussed in Section IV of this report. The time history of these plumes is shown in Figures 5 and 6.

*** 9 June 1979 ***

The second day of the experiment was ideal in many ways. The barometer had stabilized at 30.3" of Hg. and the skys were still bright and clear. The plumes that were generated demonstrated a classical performance, staying together in a well defined cloud and drifting downwind in the gentle 12 mph wind. They were capable of being tracked by the aircraft for periods of time of up to 23 minutes after the production of the plume.

The aircraft profiles (Figure 7c, d) of air temperature and relative humidity showed a well defined marine layer with a sharp inversion at 500 meters and a constant relative humidity of approximately 80% between this layer and the sea surface. The TALA wind profile (Figure 7a, b) showed very little wind shear above 20 meters thus the marine layer acted as almost a passive conduit through which an artificial fog passes relatively unscathed by eddy turbulent processes. The pilot reported that these plumes would pass out to sea in an undisturbed fashion until they came to an invisible transition area where they would rapidly disappear. The pilot also observed white water phenomenon at the sea surface as well as clear air turbulence to the aircraft in the same general location where the plumes disappeared. The data from this day probably does not tell us too much of the relative merits of the two salty dog materials as they both worked well in this environment. The experiment does demonstrate the potential value of the material as a screening layer for operational use.

The first four plumes of this day are the four combinations of materials and processes. Figure 8a, b and Figure 9a, b are the delay curves for: NWC29 unstabilized; CY85A unstabilized; NWC29 stabilized; and CY85A stabilized, respectively. The last plume generated on this day, Figure 9c

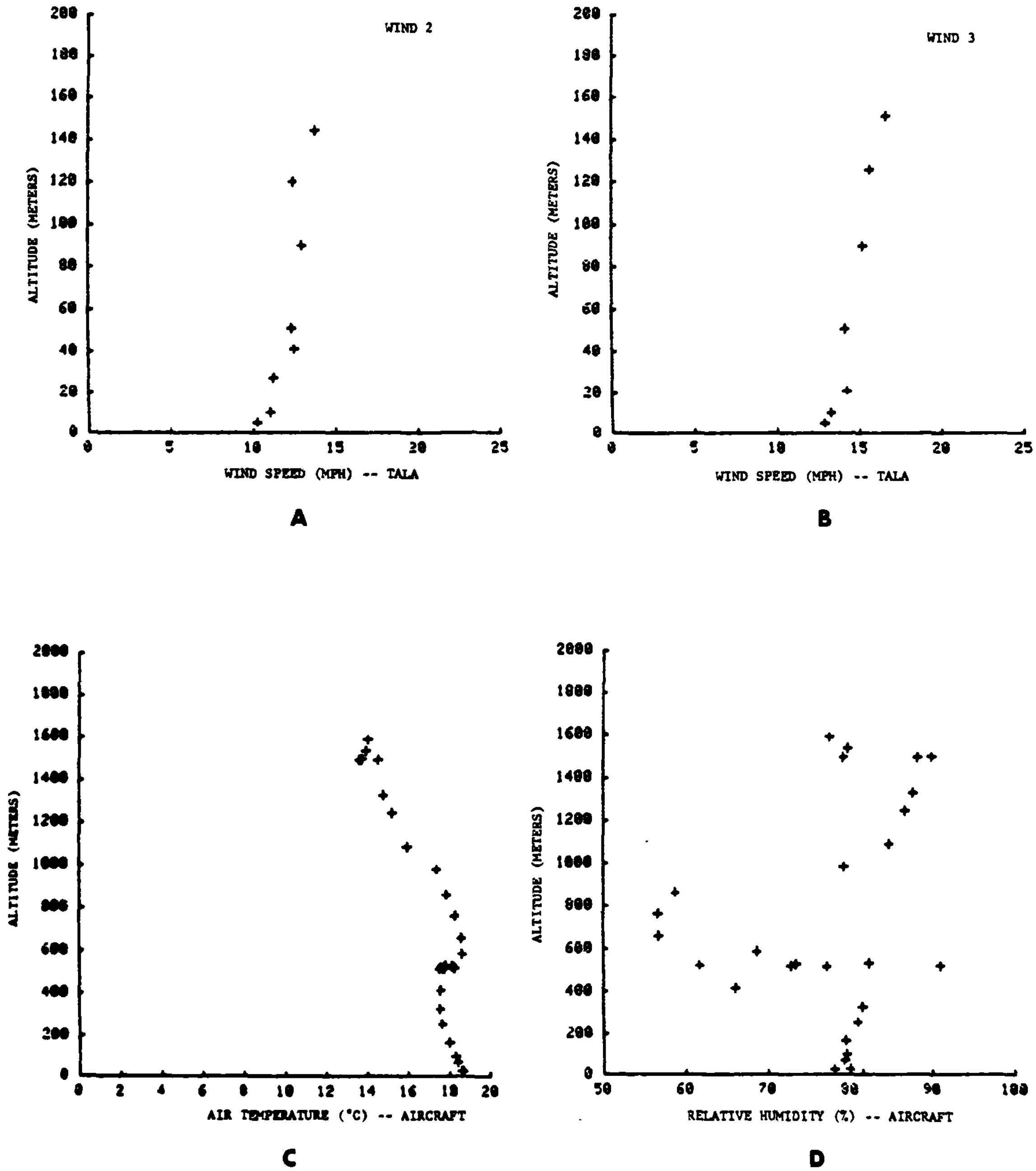


Fig. 7. Meteorological conditions on 9 June 1979.

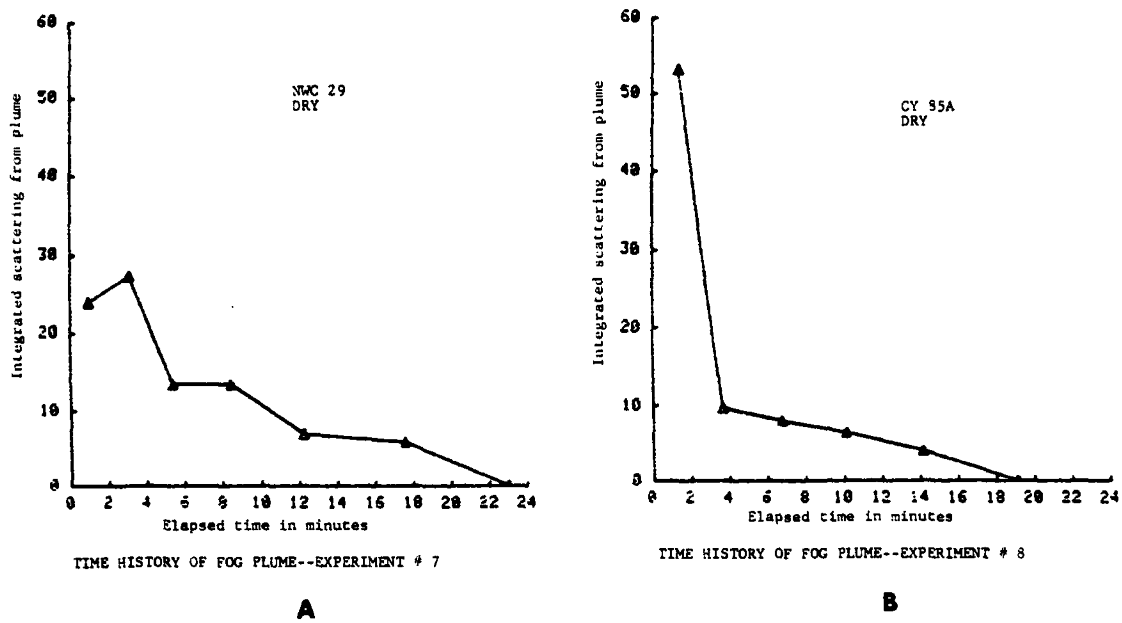
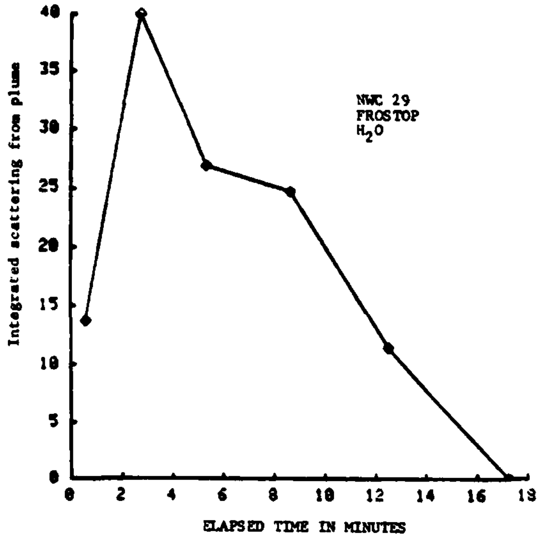
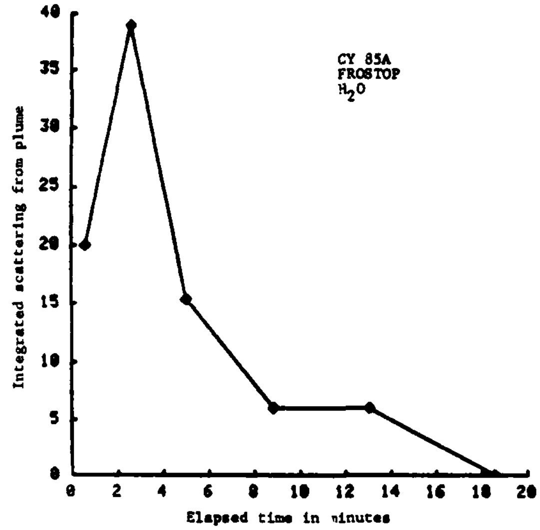


Fig. 8. Time histories of fog plumes 7, 8. (9 June 1979)



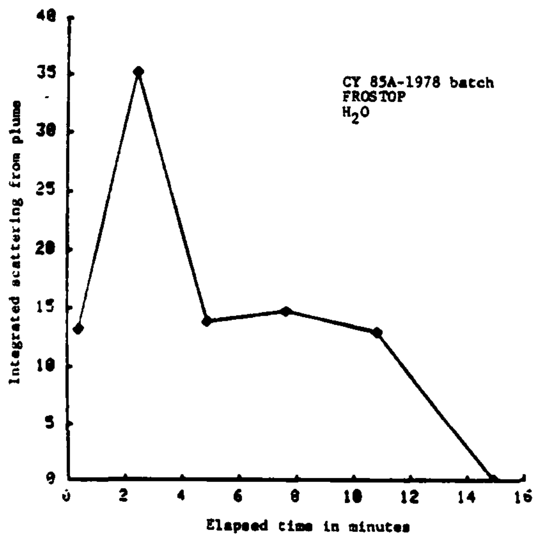
TIME HISTORY OF FOG PLUME--EXPERIMENT # 9

A



TIME HISTORY OF FOG PLUME -- EXPERIMENT # 10

B



TIME HISTORY OF FOG PLUME -- EXPERIMENT # 11

C

Fig. 9. Time histories of fog plumes 9, 10, 11. (9 June 1979)

consisted of a 431 gm block of the same batch of salty dog material used in the 1978 field test and stabilized with the Frostop process. Its performance seems to be inferior to the other experiments even though there is more material for the generation process.

*** 10 June 1979 ***

The third day of the experiment contained a series of tests done during an instability which essentially destroyed the conduit so beautifully displayed the day before. The barometer showed a decreasing pressure of 30.21" of Hg. The day was very clear with relative humidity reading in the mid 70% range on the beach. The airborne measurements (Figure 10) showed no strong temperature inversions anywhere in the lowest 1600 meters of the atmosphere. The airborne relative humidity profile showed scattered readings between 75% and 90% in the area below 1000 meters. The wind speed profiles (Figure 11) showed constant values of about 13 mph above 30 meters.

The sand temperature of 42 C as measured with the IR thermometer was apparently causing convective activity which acting together with a weak general wind flow caused a confused wind direction on the beach. Once the plumes were generated, they seemed to have trouble leaving the site of the generator, meandering about at first and then seemingly escaping from the invisible canopy and flowing off down wind with the general flow. Data taken on this day will not compare favorably with other days because of this meandering phenomenon but intercomparisons of data all experiencing this phenomena will still be valid. The time histories of the plumes of this day are shown in Figures 12 and 13.

*** 11 June 1979 ***

The meteorological conditions on the fourth day of the experiments were ideal in many ways. The sky was clear at 11:30 EDT at the beginning of the tests. The relative humidity measured on the beach at this time was 78%. The IR thermometer showed a sea surface temperature of $18^{o}C$ and a sand temperature of $42^{o}C$. The wind direction was from 180^{o} at an approximate

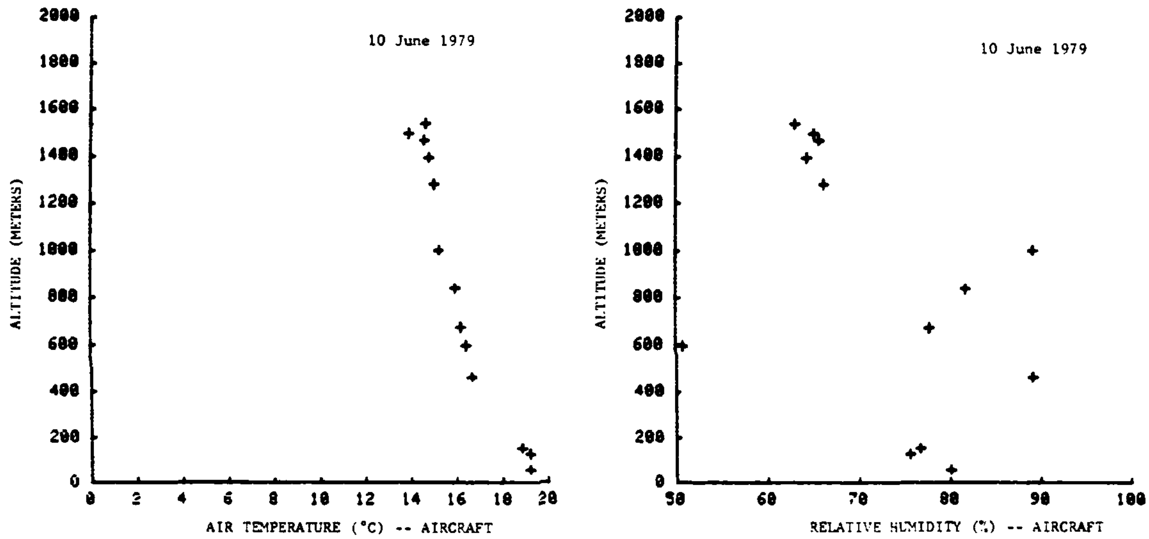


Fig. 10. Temperature and relative humidity on 10 June 1979.

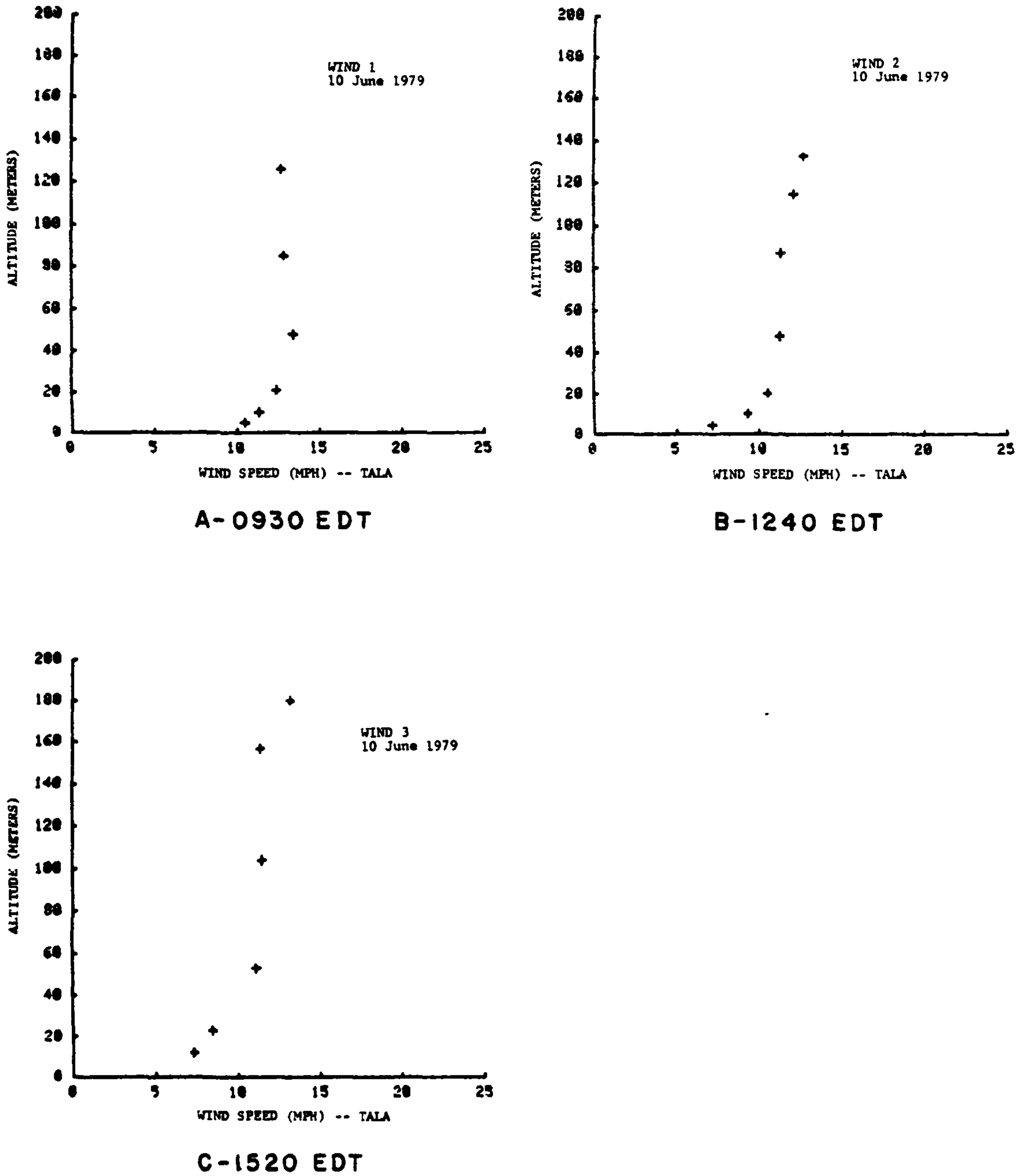
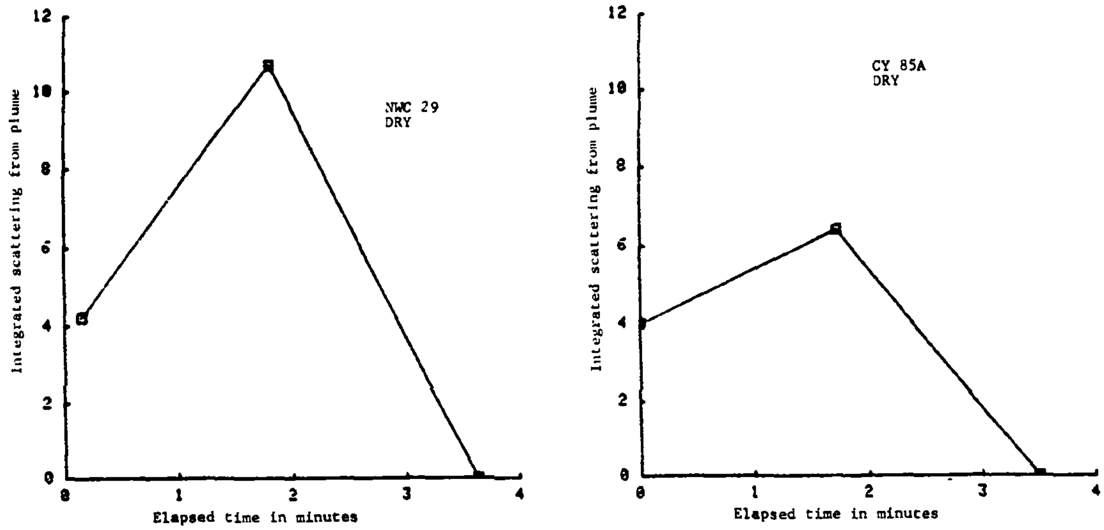


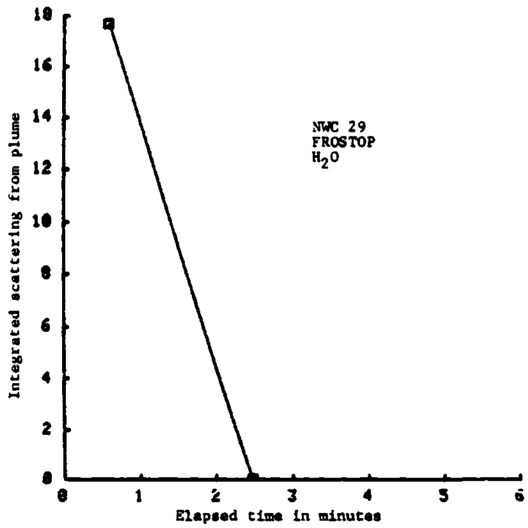
Fig. 11. Wind profiles on 10 June 1979.



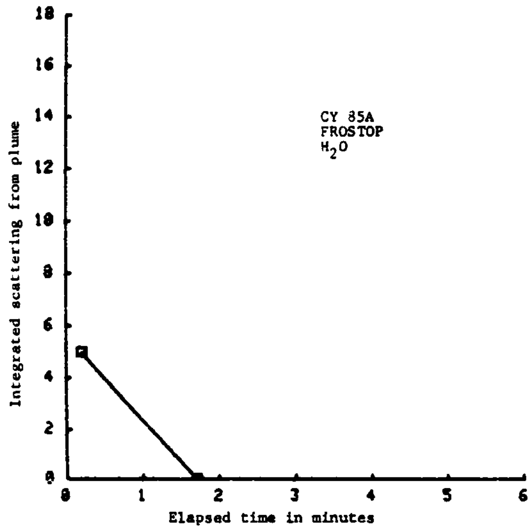
TIME HISTORY OF FOG PLUME--EXPERIMENT # 12

TIME HISTORY OF FOG PLUME--EXPERIMENT # 13

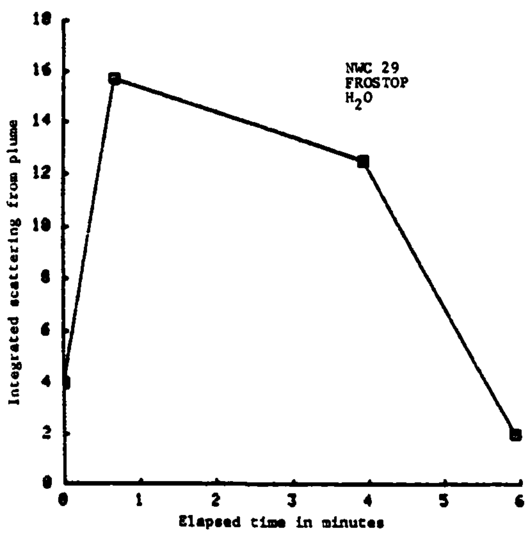
Fig. 12. Time histories of fog plumes 12, 13. (10 June 1979)



TIME HISTORY OF FOG PLUME--EXPERIMENT # 14



TIME HISTORY OF FOG PLUME--EXPERIMENT # 15



TIME HISTORY OF FOG PLUME--EXPERIMENT # 16

Fig. 13. Time histories of fog plumes 14, 15, 16. (10 June 1979)

speed of 13-18 miles per hour. At 15:30 EDT at the end of the experiment the wind had shifted to 225^{o} and a wind speed range of 12 to 22 mph over the altitude range of 5 to 161 meters. At the same time the sky showed signs of clouding up and the relative humidity measured on the shore rose to 86%. A frontal passage came through the area several hours after the experiment.

The plumes generated on this day demonstrated classic plume behavior remaining well defined as they traveled with the wind in the marine boundary layer several kilometers downwind.

An analysis of the wind speed profile (Figure 14) showed no shear above 50 meters prior to the first plume of the day. At the conclusion of the day's measurements the profile showed a wind shear to 170 m. This is consistent with the aircraft temperature and dewpoint sounding taken prior to the series of tests.

The time histories of the plumes are shown in Figures 15, 16, 17, and 18. The effect of stabilizing the droplets against evaporation as compared with no stabilization of the droplets is quite evident from the results of these tests. The reasons for this will be discussed in a later section.

*** 12 June 1979 ***

The final day of experiments (12 June 1979) following the frontal passage of the night before, the anemometer indicated a wind speed at 10 meters to be about 28.7 mph from a direction of 260^{o}, Figure 19A.

There was evidence of airborne salt aerosol being produced by white caps and surf. These were detected on the surface area instrument and appeared as signals downwind of the surf zone.

The temperature profile, Figure 19B, indicated an unstable situation in the boundary layer with an inversion at 900 meters. The relative humidity at the surface measured 78% and stayed between this value and 85% in the first 900 meters above the water (Figure 19C).

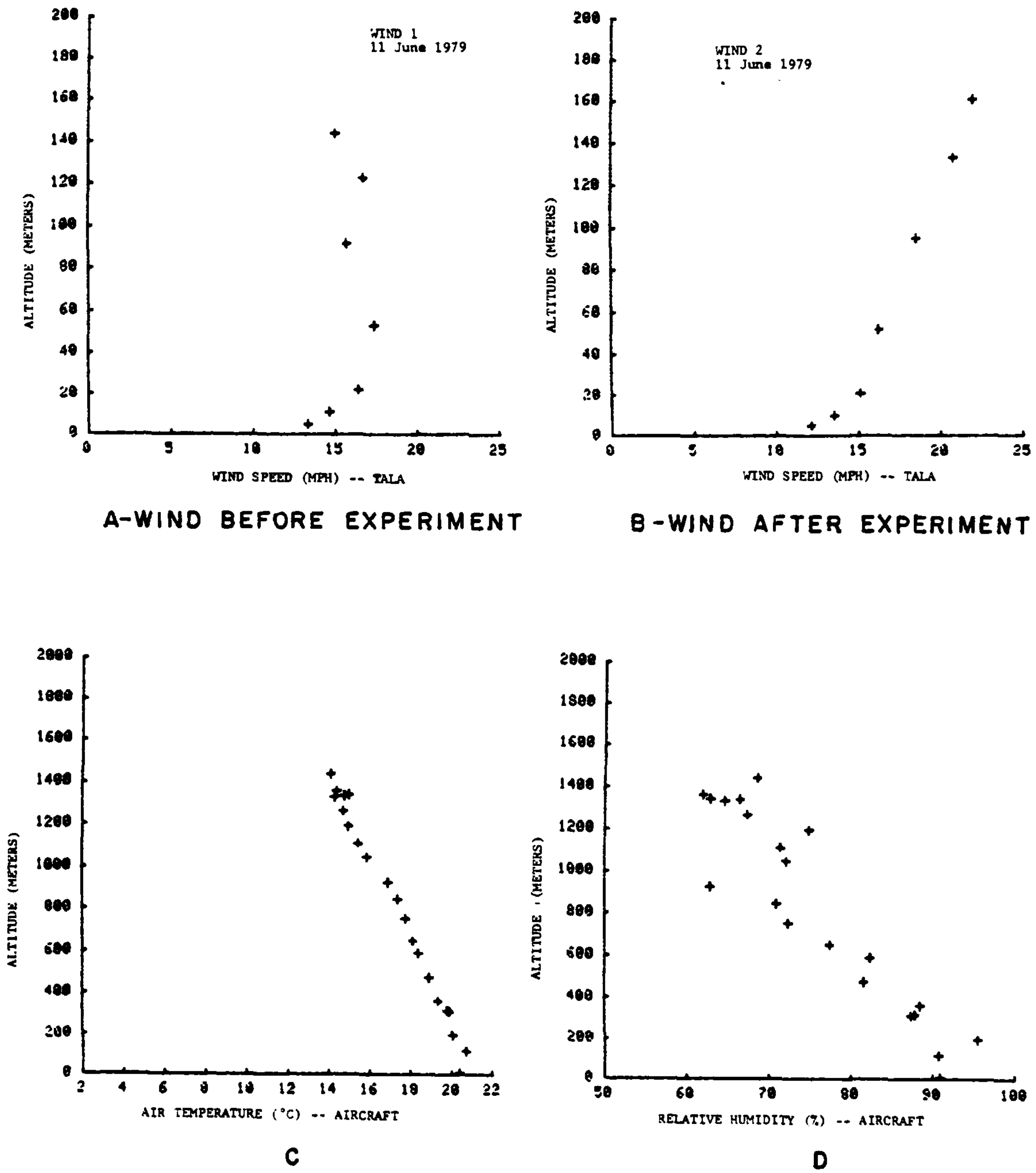


Fig. 14. Meteorological conditions on 11 June 1979.

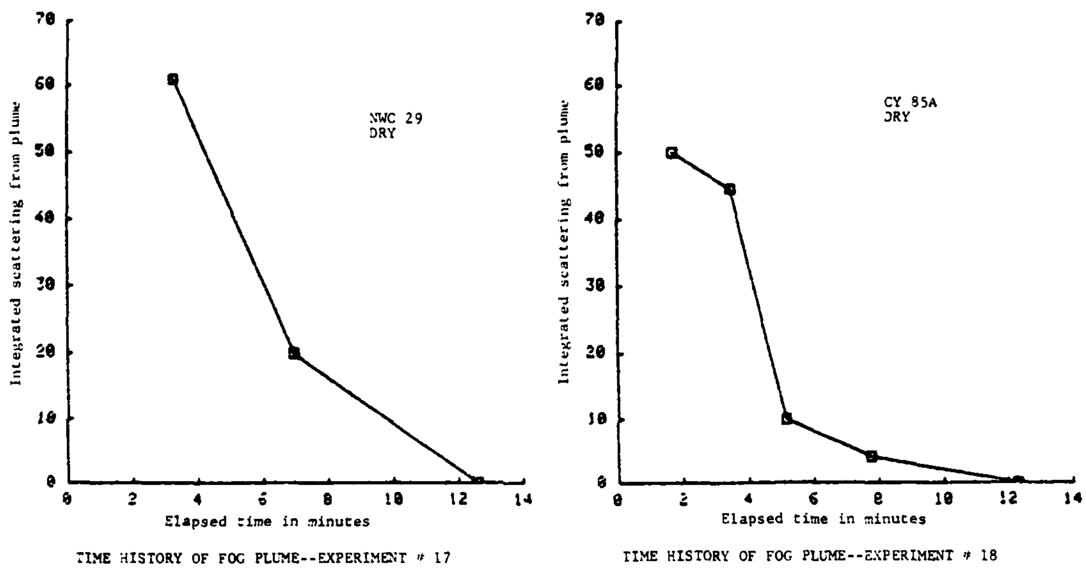


Fig. 15. Time histories of fog plumes 17, 18. (11 June 1979)

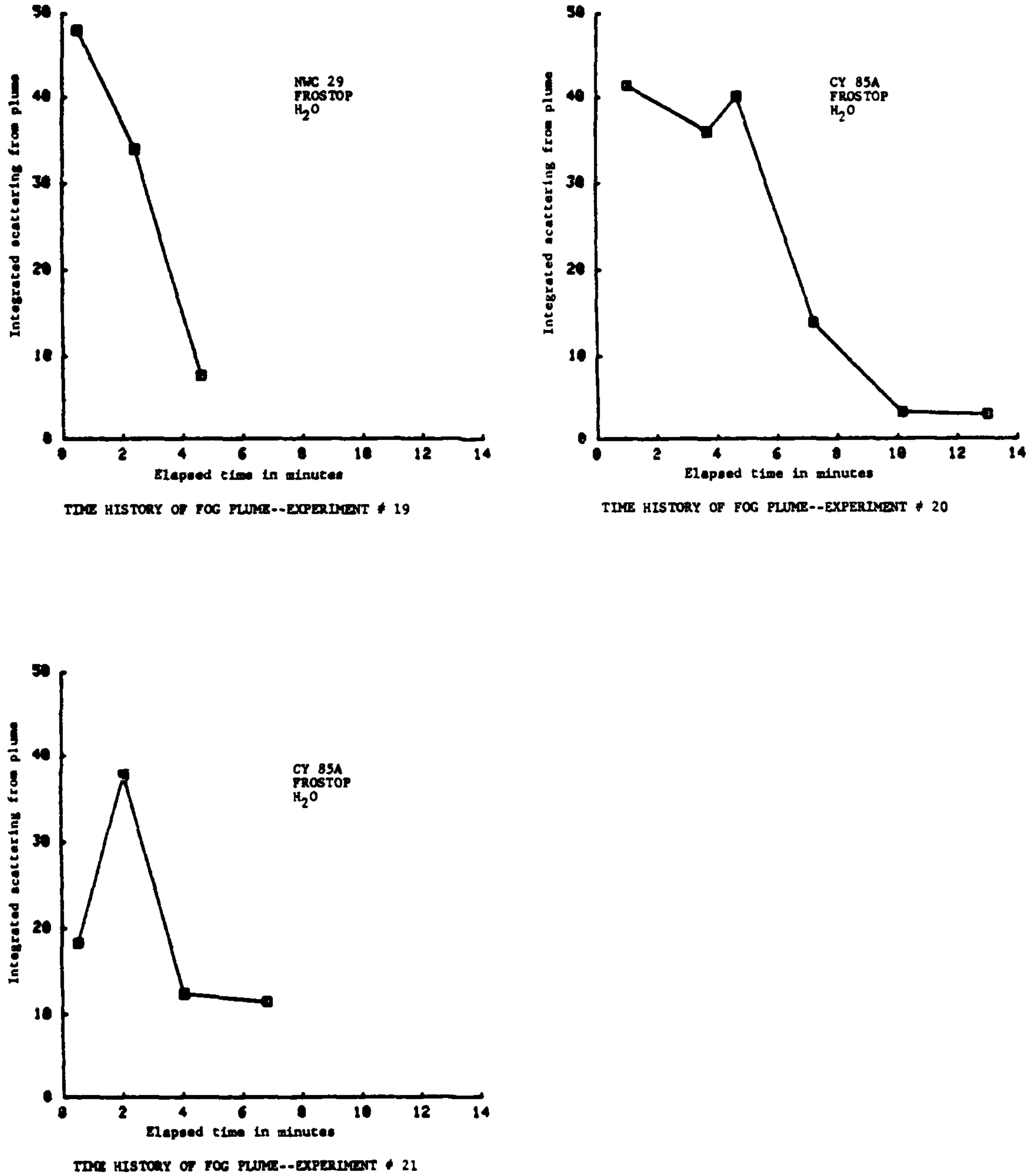


Fig. 16. Time histories of fog plumes 19, 20, 21. (11 June 1979)

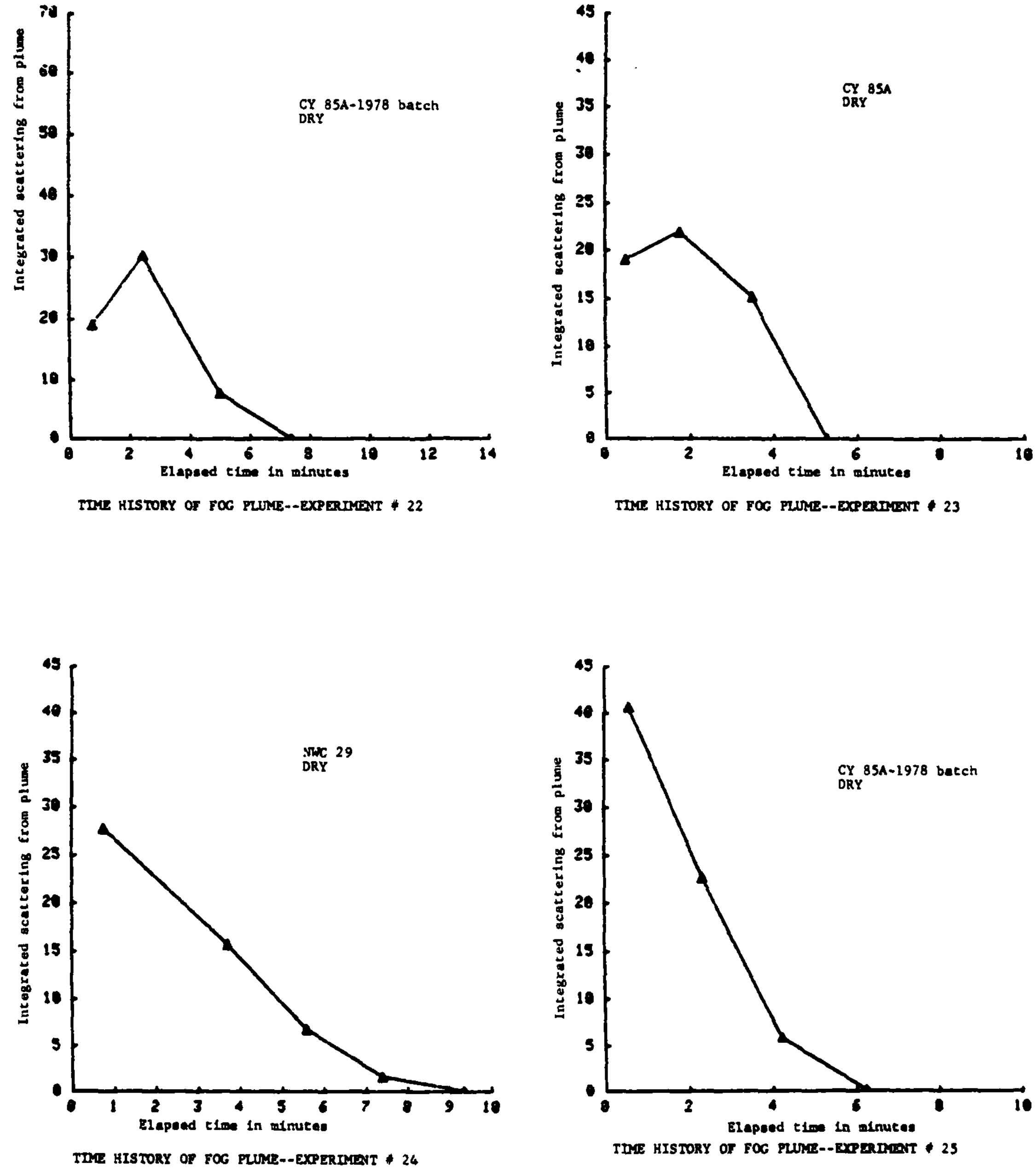


Fig. 17. Time histories of fog plumes 22, 23, 24, 25. (11 June 1979)

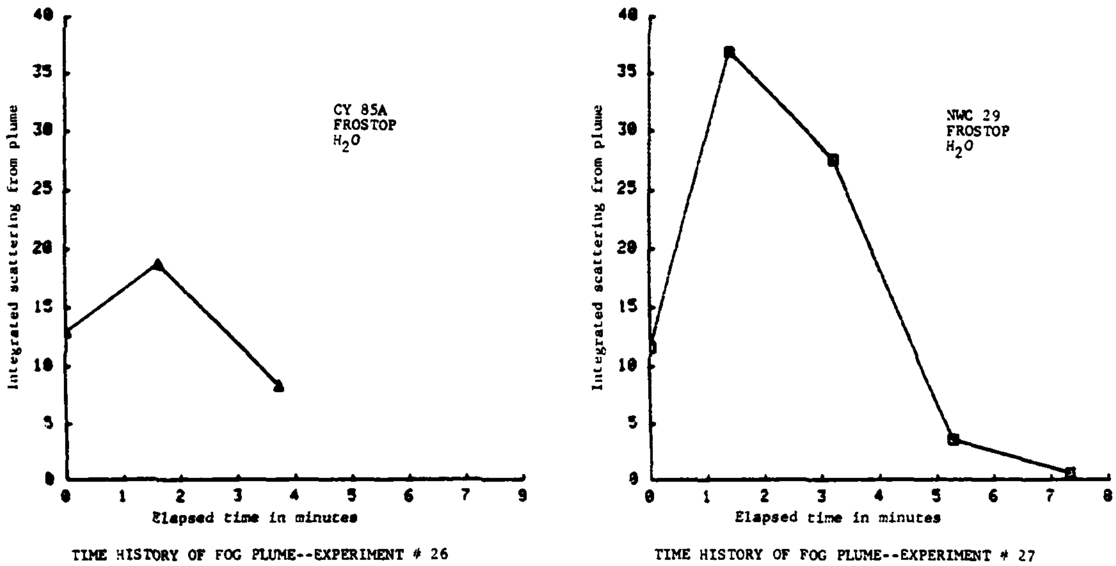


Fig. 18. Time histories of fog plumes 26, 27. (11 June 1979)

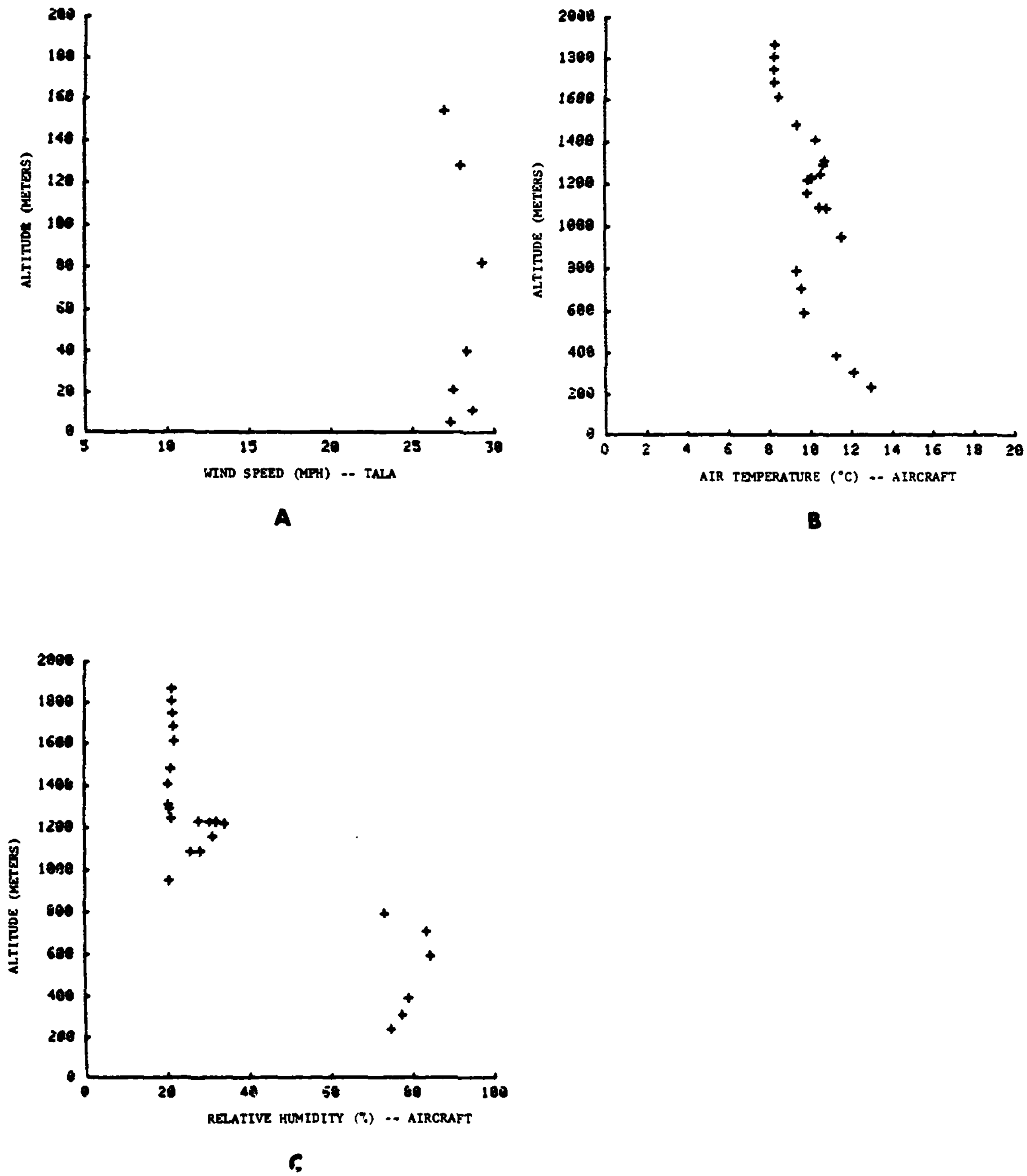


Fig. 19. Meteorological conditions on 12 June 1979.

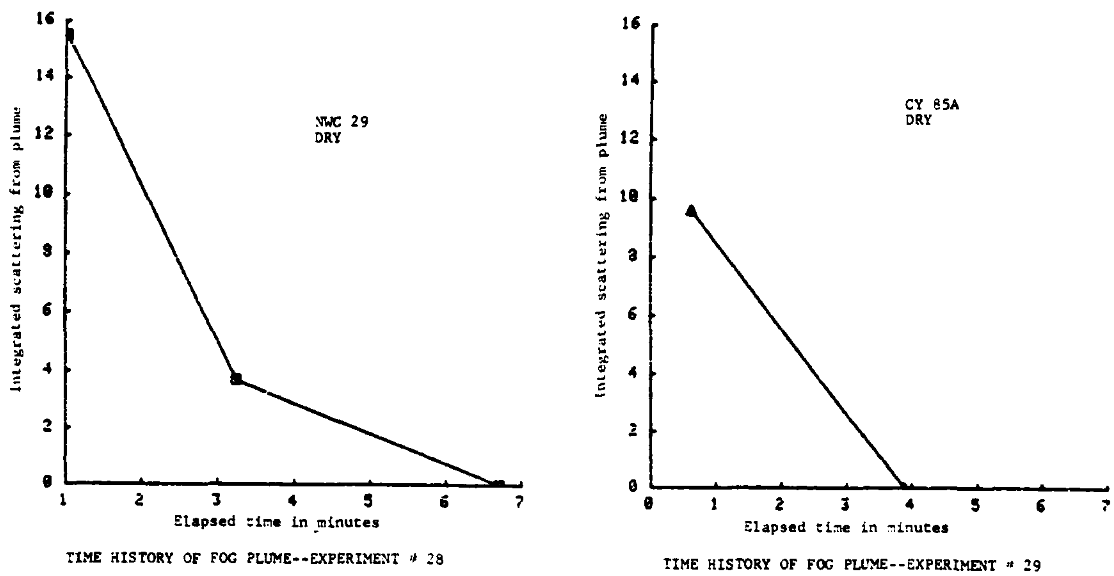


Fig. 20. Time histories of fog plumes 28, 29. (12 June 1979)

The time history plots for the four plumes produced on this day (Figures 20 and 21) show clearly the stabilizing effects of the surfactant treatment of the droplets. The last two "treated" plumes lasted significantly longer than did the initial two untreated plumes.

IV. EXPERIMENTAL RESULTS

One result of the five days of experiments on Nantucket in June 1979 can be expressed as a set of performance comparisons between the newer (NWC-29) and older (CY85A) hygroscopic pyrotechnic compositions. In all cases equivalent amounts of pyrotechnic were burned. We may compare them when they are both introduced as untreated nuclei into the atmosphere under identical conditions. The effectiveness of the enhanced growth and stabilizing treatment can also be determined for either type of nuclei material. This is accomplished when the same type of pyrotechnic material produces nuclei which are then grown to size and treated with a monolayer coating of an evaporation retardent and the results compared with the performance of the similar experiment without the special treatment. Throughout the five days of the field experiments, pairs of experiments were performed under identical external conditions differing from each other either in type of pyrotechnic material used in their generation or whether or not the generated nuclei were treated by the enhancing and stabilizing technique.

The measurements made with the aircraft provide the data by which we may characterize the plumes in several ways. These are the maximum integrated scattering area observed during the penetration of the plume, the duration of the plume and the occurrence of larger droplet size indicated by an electrostatic sampler indication are three measures of the comparison which are shown in Table 1. The table shows the dates of the comparisons and the range of relative humidities measured at the site of the experiment throughout the time of the experiment. For each of the performance catagories the plume of droplets grown on CY85A formulation nuclei was compared with a similar plume grown on the NWC29 formulation. The formulation which performed the best (in the untreated generation mode) was marked with an "X". No "X" appears in the position if data was not available on that experiment or if identical results were obtained for both candidates in the comparison.

In the comparison between the substances shown in Table 1, it appears that the NWC29 formulation outperformed the CY85A formulation in 2/3 of the cases in terms of the maximum visible scattering observed in the penetrations of the plume.

In looking at results of the duration tests between fogs produced by the two pyrotechnic materials (for the untreated case) the results showed that the newer formulation is clearly a winner being better than the older formulation in 83% of the comparisons. This is a direct result of the chemist's effort in lowering the eutonic point of the salts to achieve growth at lower relative humidities.

In the available measurements of the sizing characteristics of the population of aerosol in the plumes in which the two generating materials were compared, more larger droplets were observed in plumes generated from the old formulation than from the new.

In general it appears that the nuclei produced by the newer formulation in an untreated state are superior in duration and scattering ability of the plume to the older formulation. The older CY85A formulation shows relatively superior performance in the production of large aerosols (these being important in the interaction with infrared wavelengths). These results may perhaps be the result of the dry size nuclei produced by the temperature of the burning process and may perhaps be adjustable by manipulation of the formulation materials.

We now turn our attention to the relative merits of these formulations as condensation nuclei upon which to grow and then to stabilize the droplets against further evaporation. Table 2 is the score sheet from the experiments at Nantucket which describe the comparisons between treated and nontreated fogs based on nuclei made from the older (CY85A) pyrotechnical material.

The data presented in Table 2 shows that the stabilization technique actually decreased the maximum optical scattering ability in the largest percentages of the cases although the duration of the plume was prolonged when the treatment method was used. These tests also indicate that the largest sizes of droplets occur in the treated fogs as we would expect from the first principles of the operation of the Nantucket fog stove. These results show however that this is a measurable result and not just a theoretical prediction.

Table 3 is the score sheet from the Nantucket comparison between treated and nontreated fogs when the new NWC29 formulation was used as the basic aerosol generator. From this data we see that there is an indication that the growth and stabilization technique had opposite effects from the comparisons for the catagories of the maximum scattering of the plume and the apparent life time of it. The treatment of the material increased the maximum scattering of the clouds but tended to shorten its life. In this case as in the tests of the older material the larger particles occur when the growth and stabilization technique is applied.

In conclusion it can be stated that the non-stabilized NWC29 material is an improvement over the older non-stabilized CY85A material in both the maximum observed optical scattering and in the overall duration of the fog. In the area of larger droplets however the CY85A material was superior in terms of these limited tests. From these tests there is evidence to believe that the treatment with water vapor and a surfactant does not improve the CY85A performance in the area of maximum visible wavelength scattering although it will increase the droplet sizes and thus influence the infrared interaction with the aerosol as well as increase its duration. This treatment however increases the maximum scattering and the large particle performance of the NWC29 material but tends to reduce and not to increase its already good duration qualities.

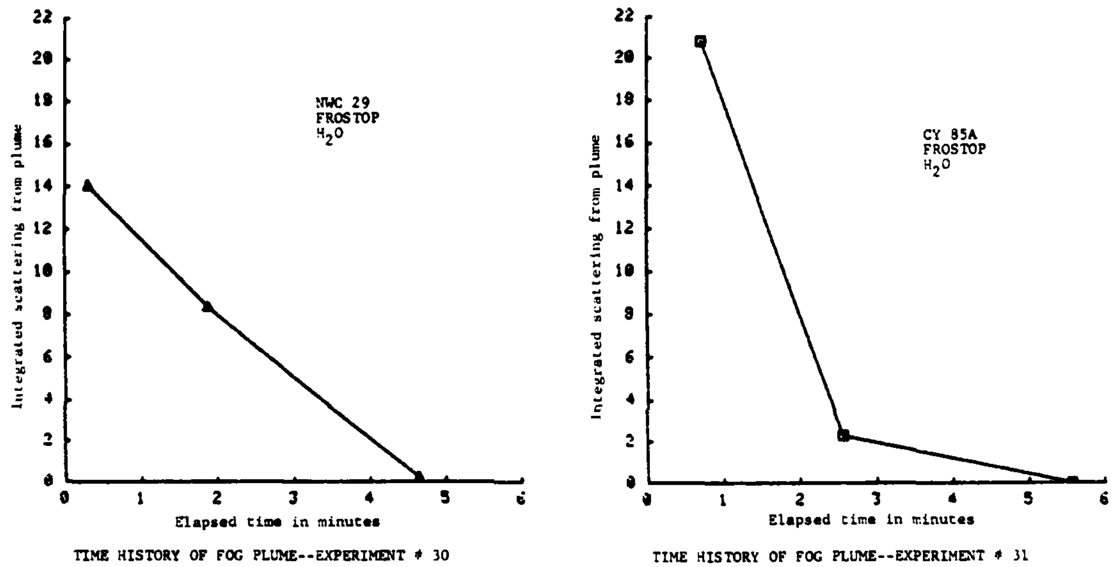


Fig. 21. Time histories of fog plumes 30, 31. (12 June 1979)

TABLE 1. PERFORMANCE OF OLD FORMULA CY-85A VERSUS NEW FORMULA NWC-29 IN DRY TREATMENT.

		MAXIMUM SCATTERING		DURATION OF PLUME		ELECTROSTATIC INDICATION	
DATE	AIR REL.HUMID	NEW NWC-29	OLD CY-85A	NEW NWC-29	OLD CY-85A	NEW NWC-29	OLD CY-85A
JUNE 8	56%		X	X			X
9	74		X	X			X
10	73-85	X			X		
11	78-86	X		X			X
11	78-86	X		X			
12	78	X		X			
PERCENTAGE OF OCCURENCE		67%	33%	83%	17%	0%	100%

TABLE 2. PERFORMANCE OF OLD FORMULA, CY-85A, PYROTECHNIC; DRY VERSUS GROWTH AND STABILIZATION TREATMENT (FROSTOP OR CETYL ALCOHOL).

	MAXIMUM SCATTER		PLUME DURATION		ELECTROSTATIC INDICATION	
REL HUMID	DRY	WITH TREATMENT	DRY	WITH TREATMENT	DRY	WITH TREATMENT
56%	X			X	X	
74	X					X
73-85	X		X			X
78-86	X			X		X
78-86		X		X		
78-86	X					
78		X		X		
PERCENTAGE OF OCCURENCE	71%	29%	20%	80%	25%	75%

TABLE 3. PERFORMANCE OF NEW FORMULA PYROTECHNIC (NWC-29); DRY VERSUS GROWTH AND STABILIZATION TREATMENT (FROSTOP OR CETYL ALCOHOL).

	MAXIMUM SCATTER		PLUME DURATION		ELECTROSTATIC INDICATION	
REL HUMID	DRY	WITH TREATMENT	DRY	WITH TREATMENT	DRY	WITH TREATMENT
56%		X		X		X
74		X	X			X
73-85		X	X			X
78-86	X		X		X	
78-86		X	X			
78	X		X			
PERCENTAGE OF OCCURENCE	33%	67%	83%	17%	25%	75%

REFERENCES:

(1) Gathman, S.G., Julian, B.G., Markson, R.K. and Sedlàĉek, J. 1979: Field Test of the Stabilization of Supersized Water Droplets Condensed on Pyrotechnically Generated Hygroscopic Nuclei, NRL Memo Rpt 4059, 28pp.

(2) Gathman, S., 1980: Field Test of Stabilized Pyrotechnically Generated Water Fogs; Artificial Aerosols, Edited by Deepak, A. and Ruhnke, L.H., NRL Memo Rpt 4197, p 22.

(3) Mathews, L.A. and St. Amand, P., 1980: Improvements of Alkali Chloride Smokes; Artificial Aerosols, Edited by Deepak, A. and Ruhnke, L.H., NRL Memo Rpt 4197, p 59.

(4) Vonnegut, B., Moore, C.B., Ehrenfeld, J. and Smallman, C.R., 1957: Determining the concentration of fogs and other aerosols by a space-charge measuring instrument; Artificial Stimulation of Rain, Edited by Weickmann, H. and W. Smith, Pergamon Press, New York, p. 122.

APPENDIX . THE ELECTROSTATIC DROPLET SURFACE AREA DETECTOR

This little known device (Vonnegut, et al, 1957) uses the principles of electrostatics to deduce the net surface area of droplets being forced through the device by either a blower for stationary instruments or by the motion of the aircraft moving through relatively still air. Referring to Figure A-1 the electrically neutral droplets first pass through a volume, which is in unipolar point discharge. The droplets passing through this area pick up a surface electric charge proportional to their surface area by field induction. The final step in the process is to measure at a point downstream the total electric charge residing on the droplets. This is accomplished by the use of a cylindrical Faraday cage. This device is an essentially electrostatically shielded region of a cylindrical geometry. The electric potential of a point on the axis of the cylinder with respect to the cylinder cage itself is proportional, by the laws of electrostatics, to the net electric charge enclosed by the charge. The electric potential is measured by means of an extremely high impedance electrometer connected to a radioactive source located at the center of the cylindrical axis. The radioactive source producing ions of both polarities does not effect the net space charge within the cage as the space charge is the difference between positive and negative charge residing in the volume.

It does however cause the electric potential of the metal antenna on the axis of the cylinder to reach the theoretical potential produced on the axis by the net space charge within the volume, providing the antenna is not loaded down electrically. Hence, we require for this measurement an ultra high impedance electrometer voltmeter.

The field charging system is produced by an isolated ring kept at 15 kilovolts by action of a h.v. power supply. The grounded needle is in corona because of the high field in the region. A strip of polonium 210 was wrapped around the outside of the antenna probe and acted as the potential equalizer causing the d.c. voltage of the antenna to be proportional to the enclosed space charge.

In the present use of this instrument we are not using its ability to determine quantitatively the surface area of the aerosol fogs but only to complement the nephelometer to determine if indeed there are droplets present that are larger than the upper limit of the nephelometer. Hence the usual problems of a precise calibration of the device can be avoided since we are only interested in its yes/no detection information.

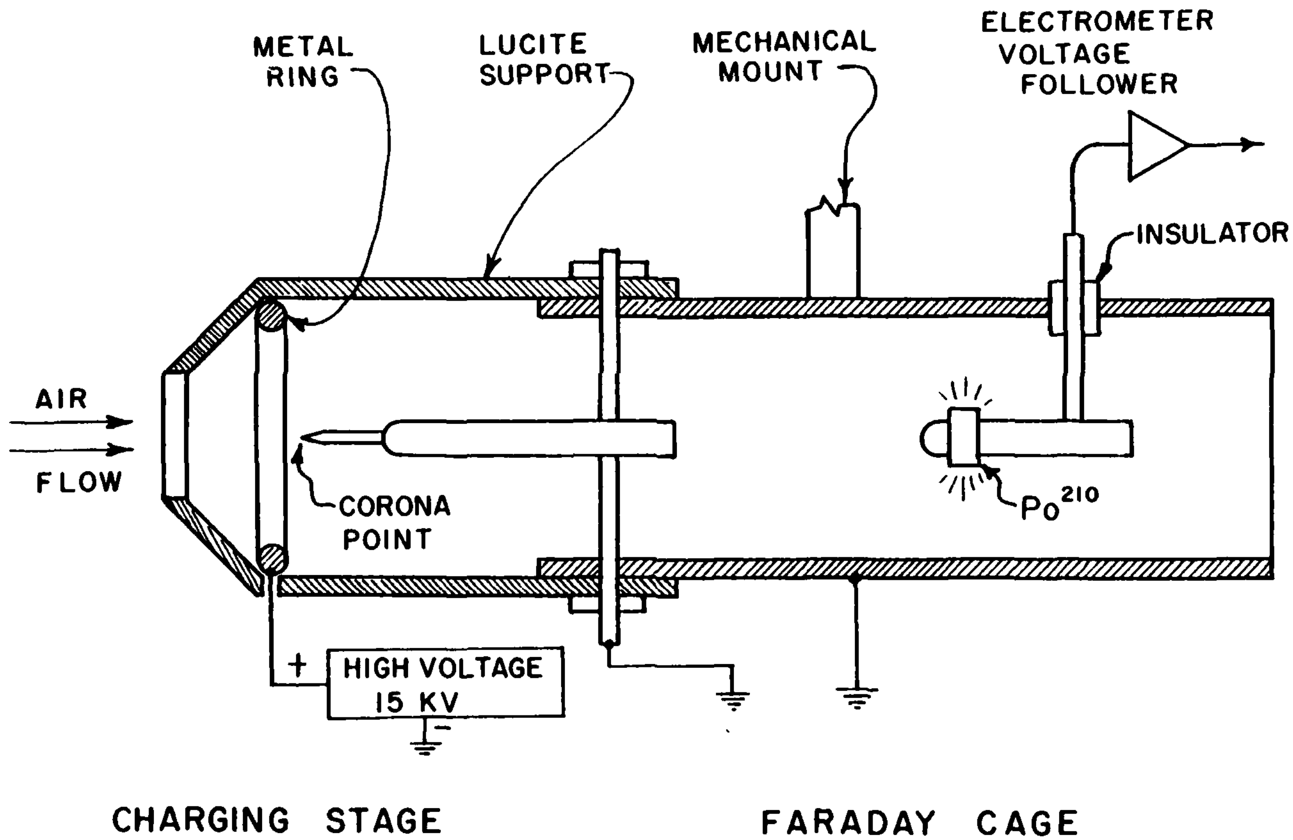


Fig. A-1. Electrostatic droplet surface area detector.

DAT

FILM